

**SECTION 1—AERONAUTICS SYSTEMS TECHNOLOGY**

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**OVERVIEW**

The technologies presented in this section are those associated with aircraft, aero gas turbine engines and the interface of humans with the aeronautics systems. These are deemed critical to maintaining the overall superiority of U.S. air forces vis-a-vis potential adversaries on land, sea and air. The technologies of concern relate to the design, integration and manufacture of systems, subsystems and components that provide for the production of operational weapons systems. Many technologies in military aviation systems are shared with and are used by commercial aviation. However, those addressed in this section have been selected in light of the unique operational performance envelopes of military systems. These include hostile environments, severe performance requirements, and the need for rapid analysis and response to hostile situations by the operators of the combat platform.

## SECTION 1.1—AIRCRAFT, FIXED WING

### OVERVIEW

This subsection addresses two technologies that are key to mission success of military aircraft, be they fixed or rotary wing, manned or unmanned. The first technology is associated with operation in high energy release environments in both conventional and nuclear battlefield arenas. Electromagnetic pulse (EMP) and radiation effects caused by conventional and nuclear blasts will destroy a military air vehicle's operational and mission related electronic equipment if they are not properly designed, integrated and protected. The technologies of interest, in electromagnetic radiation hardening, are those related to the design, integration, component selection and shielding of critical components. The second area relates to those technologies associated with the integration of the engine control system with the airframe flight control system in order to achieve optimal performance.

**Table 1.1-1. Aircraft, Fixed Wing Militarily Critical Technology Parameters**

TECHNOLOGY	Militarily Critical Parameters Minimum Level to Assure US Superiority	Critical Materials	Unique Test, Production, and Inspection Equipment	Unique Software and Parameters	Control Regimes
<b>ELECTROMAGNETIC RADIATION HARDENING TECHNOLOGIES</b>	Hardened against peak free field intensities external to the vehicle of greater than 17,000 V/m or box-level intensities of 225 V/m (e.g., Nuclear Electromagnetic Pulse, Radar, High Frequency Broadcast and High Power Microwave)	None identified	Anechoic chambers; High power, wide band RF Sources	Algorithms, CAD/CAE tools, source code, automatic verification and validation tools containing actual design values for detection of multiple, correlated soft faults in FCS computers for military application.	WA ML 9,10 MTCR
<b>PROPULSION/AIR FRAME/FLIGHT CONTROL SYSTEM INTEGRATION</b>	Equivalent time delay of < 50 milliseconds; Loop gain margin > 6.0, phase margin > 45 degrees; bandwidth > 2.5 Hz; Cooper-Harper rating < 3, minimize wetted area and minimize observables; Aircraft loss rate per flight from FCS failures < $1 \times 10^{-5}$	None identified	Pilot-in-the-loop simulators; Ground and flight testing of prototype systems.	Dynamic 6 degrees of freedom computer simulation models; CAD/CAE development software; Verification and validation tools containing actual design, fault tolerant and diagnostic parameters.	WA ML 9,10 MTCR

## SECTION 1.2—GAS TURBINE ENGINES

### OVERVIEW

Gas turbine engine technologies in this subsection cover the hot section of the engine, which includes the combustor and the turbine (power takeoff) subsections; integration of full authority digital engine control (FADEC) to real time interface with the aircraft flight control computer; and certain accessories applied to marine and armored vehicle power. In the combustor section, thermally decoupled liners allow operation at higher temperatures which result in increased performance (thrust-to-weight ratio) and longer life. Multiple domed combustors provide the capability of optimizing fuel use during different power settings to improve efficiency, reduce emissions and allow shorter length. The metallurgical structure of the blades necessary for proper performance at high temperatures and stresses is achieved through the manufacture of single crystal castings with internal cooling sections for both the turbine blades and the stationary vanes. The technology associated with the intercoolers and recuperators provides the increased power densities in gas turbines used in non-flight applications.

**Table 1.2-1. Gas Turbine Engines Militarily Critical Technology Parameters**

TECHNOLOGY	Militarily Critical Parameters Minimum Level to Assure US Superiority	Critical Materials	Unique Test, Production, and Inspection Equipment	Unique Software and Parameters	Control Regimes
<b>COMBUSTOR: THERMALLY DECOUPLED LINERS</b>	Combustors operating at average burner outlet temperatures exceeding 1,811 K (1538 °C) (2800 °F)	None identified	Production equipment for producing porous wall material; high temperature combustor material	None identified	WA IL Cat 9; WA ML 10; MCTR 3
<b>COMBUSTOR; MULTIPLE DOMED</b>	Average burner outlet temperatures exceeding 1,811 K (1538 °C) (2800 °C)	None identified	None identified	None identified	WA IL Cat 9; WA ML 10; MCTR 3
<b>BLADE ATTACHMENT BY DIFFUSION BONDING, PRESSURE BONDING, LINEAR FRICTION/INERTIAL WELDING.</b>	Bond strength at least 100% of either of the bonded parts.	None identified	Equipment to achieve and insure viable bonds.	None identified	WA IL Cat 9; WA ML 10; MCTR 3
<b>TURBINE: BLADES AND VANES WITH COOLING PASSAGES PRODUCED BY LASER, WATER JET, OR ECM/EDM HOLE DRILLING PROCESSES TO ALLOW FOR AIR FILM COOLING</b>	Hole depths greater than 4 times the diameter, with diameters less than 0.76 mm and incidence angles equal to or less than 25°; or hole depths > 5 × diameter, diameters < 0.4 mm	None identified	Equipment to use the various technologies to achieve hole initiation with the desired entrance and exit hole geometric and metallurgical characteristics.	None identified	WA IL Cat 9; WA ML 10; MCTR 3

(Continued)

**Table 1.2-1. Gas Turbine Engines Militarily Critical Technology Parameters (Continued)**

TECHNOLOGY	Militarily Critical Parameters Minimum Level to Assure US Superiority	Critical Materials	Unique Test, Production, and Inspection Equipment	Unique Software and Parameters	Control Regimes
<b>TURBINE: SINGLE CRYSTAL CAST COOLED TURBINE BLADES AND VANES.</b>	Single crystal alloys having (in the < 001 > Miller Index Direction) a stress rupture life exceeding 400 hours at 1273 K (1,000 C) at a stress of 200 MPa, based on the average property values.	None identified	Casting cores and shells; Ceramic core manufacturing equipment, leaching apparatus, ceramic core wax pattern preparation equipment, and ceramic shell burnout or firing equipment.	None identified	WA IL Cat 9; WA ML 10; MCTR 3
<b>FULL AUTHORITY DIGITAL ENGINE CONTROL (FADEC) SYSTEMS WITH REAL TIME INTERFACE WITH A/C FLIGHT CONTROL COMPUTER.</b>	Equivalent time delay of < 50 milliseconds; Loop gain margin > 3.0, phase margin > 45 degrees, bandwidth > 1.5 Hz; Engine loss rate per flight from engine control failures < $1 \times 10^{-5}$	None identified	None identified	High speed computer models; CAD development software	WA IL Cat 9; WA ML 10; MCTR 3
<b>VARIABLE GEOMETRY ENGINES INCORPORATING INTERCOOLERS AND/OR RECUPERATORS IN MARINE APPLICATIONS.</b>	Marine GTEs with ISO rating of 24,245 kW (32,500 Hp) or more and SFC < 0.219 kg/kW-hr (0.360 lb/hp- hr) in range of 35–100 percent ISO standard continuous power.	None identified	None identified	None identified	WA IL Cat 9; WA ML 10

## SECTION 1.3—HUMAN (CREW) SYSTEMS INTERFACES

### OVERVIEW

This subsection covers all the interactive mechanisms between a crew member and the vehicle he is operating or operates in. Many of the items in the broad category are truly dual use in commercial spacecraft, aircraft, watercraft and ground vehicles. The technology includes the utilization of human factor data bases to match the human physiological requirements to the sensing of information and the subsequent interactions taken with machinery, computers, etc. The militarily critical portion of this area resides in the technologies associated with helmet mounted displays and the ability to cause interactions with some of the mission equipment through the use of the helmet capabilities. An example would be the pointing of a weapon being coupled with the helmet position of a helicopter weapons operator. Such helmet mounted capabilities are unique to the successful military mission accomplishment. The technologies also include the integration of display capabilities in a high resolution yet lightweight, low power (low heat generating) mode that will not restrict or fatigue the user.

**Table 1.3-1. Human (Crew) Systems Interfaces Militarily Critical Technology Parameters**

TECHNOLOGY	Militarily Critical Parameters Minimum Level to Assure US Superiority	Critical Materials	Unique Test, Production, and Inspection Equipment	Unique Software and Parameters	Control Regimes
PILOTS/ FLIGHT CREW HELMET MOUNTED DISPLAYS	Lightweight, (1-2 pounds), High resolution HDTV ABV, Color 16 bit.	None identified	None identified	None identified	WA ML 10